APPENDIX III: James Streit 7/21/99 communication concerning fire protection for LH2 target

To: klaffky@LANL.GOV, joycer@LANL.GOV
Subject: Fire Protection Input for Proposed Liquid H2 at MPF-30 (ER-2) FP#12
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Roger and Joyce:

Thank you for the opportunity to review preliminary design drawings of the proposed new FP#12 equipment. The subject flight path will be instrumented with a liquid H2 (LH2) target located within a newly constructed cave. The anticipated volume of LH2 is 20 liters (~5.3 gal.). The target will be vacuum-jacketed and also Helium-jacketed. The anticipated volume of the target-enclosing cave is 60 cubic meters (~2120 cu.ft.). Our review of applicable fire protection requirements for the above referenced project yields the following:

1. Because the anticipated volume of LH2 < 150 liters (~40 gal.), the requirements of NFPA 50B, Standard for Liquefied Hydrogen Systems at Consumer Sites, do not necessarily comply to this proposed system. However, some requirements contained within this standard are universally applicable for any LH2 system and others need to be considered:

Section 2-1 -- stationary LH2 storage containers should comply with the ASME Boiler and Pressure Vessel Code, Section VIII. Portable H2 containers should comply with USDOT specifications and regulations.

Section 2-4 -- stationary LH2 containers should be equipped with pressure relief devices sized per Compressed Gas Association (CGA) S-1.3. portable H2 containers should be equipped with pressure relief devices sized per CGA S-1.2.

Sections 2-4.1/3-1.5 -- pressure relief devices need to be arranged to discharged unobstructed to the outdoors at a minimum elevation of 25 ft. above grade and a safe location, and shall not impinge upon the storage container, adjacent structures or personnel.

Sections 2-5.1/2-6.1 -- piping, tubing, fittings, valves, gages, regulators and associated equipment shall be suitable for liquid and

gaseous H2 service at the anticipated pressures and temperatures. Reference ANSI B31.3, Chemical Plant and Petroleum Refinery Piping.

Section 2-6.4 -- cabinets or housings containing H2 control equipment need to be ventilated to prevent the accumulation of H2.

Section 2-9 -- electrical wiring and equipment should be in accordance with Article 501 of NFPA 70, National Electrical Code. Division 1 electrical equipment should be used within 3 ft. of connection points are regularly made and disconnected in H2 systems. Division 2 electrical equipment should be used between 3 ft. and 25 ft. of connection points are regularly made and disconnected in H2 systems. When electrical equipment approved for Class I, Group B atmospheres is not commercially available, the equipment may be: (1) purged or ventilated in accordance with NFPA 496; or (2) intrinsically safe; or (3) approved for Class I, Group C atmospheres.

Section 2-10 -- the LH2 container and associated piping shall be electrically bonded and grounded.

Section 3-3 -- the location of the LH2 system within ER-2 should meet the following guidelines;

(a) locate at least 20 ft. from all flammable/combustible liquids and other combustibles.

(b) locate at least 25 ft. from ordinary electrical equipment, process equipment, other ignition sources

(c) locate at least 50 ft. from ventilation and compressor system intakes.

(d) locate at least 50 ft. from storage of other flammable or oxidizing gases.

(e) protect containers from physical damage (see NFPA 55 also).

(f) containers firmly secured in upright position (see NFPA 55 also).

(g) welding, cutting and other hot work activities are prohibited in ER-2 while H2 is present.

The use of the H2 gas cylinder supporting the LH2 system with ER-2 needs to comply with applicable requirements of NFPA 55, Storage, Use and Handling of Compressed and Liquefied Gases in Portable Cylinders. A single H2 portable cylinder does not pose unacceptable fire protection issues within ER-2 when the stipulated (and really common sense) requirements of NFPA 55 are applied. Examples include: valving, pressure regulating and relief, protection of the cylinder and piping, etc.

NFPA 45, Fire Protection for Laboratories Using Chemicals, was also reviewed. The requirements related to compressed and liquefied

gases generally mimic those listed above. Of particular interest to a designer would be Section 8-1.5 on cylinder safety.

If the applicable requirements and recommended guidelines of NFPA 45, 50B and 55 are incorporated into the system design, the existing fire protection provisions within ER-2 should be sufficient to adequately protect the hazards presented by the LH2 system of FP#12. The most effective means of fire suppression for a H2 fire is the isolation (or exhaustion of) the H2 source. The automatic sprinkler system of ER-2 will contain the fire to the area of origin, while cooling exposed equipment.

Final Issues to Consider: As a general rule, the conversion of LH2 to gaseous form at standard conditions results in a volume increase of approx. 850 times per NFPA 50B. A full leak of the 20 liters of LH2 results in approx. 17,000 liters (17 cubic meters) of gaseous H2. Such a leak inside the enclosing cave (60 cubic meters of air; 47.4 cubic meters of N2, 12.6 cubic meters of O2) - if assumed to be air-tight - creates an atmosphere of 22% H2, 16% O2 and 62% N2 (all rough volume %'s). Such a mixture is flammable/explosive (H2 flammable range is 4-74% in air) and creates an oxygen-depleted environment. The safety/hazard design analysis review effort will need to ascertain whether safety provisions similar to those employed for the Target 1L LH2 moderator system are required to preclude a flammable/explosive environment are warranted. The safety/hazard design analysis review effort will also have to ascertain whether personnel safety provisions like the O2 sensor and warning system employed within ER-1 are necessary to prevent asphyxiation are warranted.

I hope this provides the kind of input you were expecting. We sincerely appreciate the opportunity to review these types of activities at this early stage to help achieve the desired end product for all.

Regards,

Jim Streit